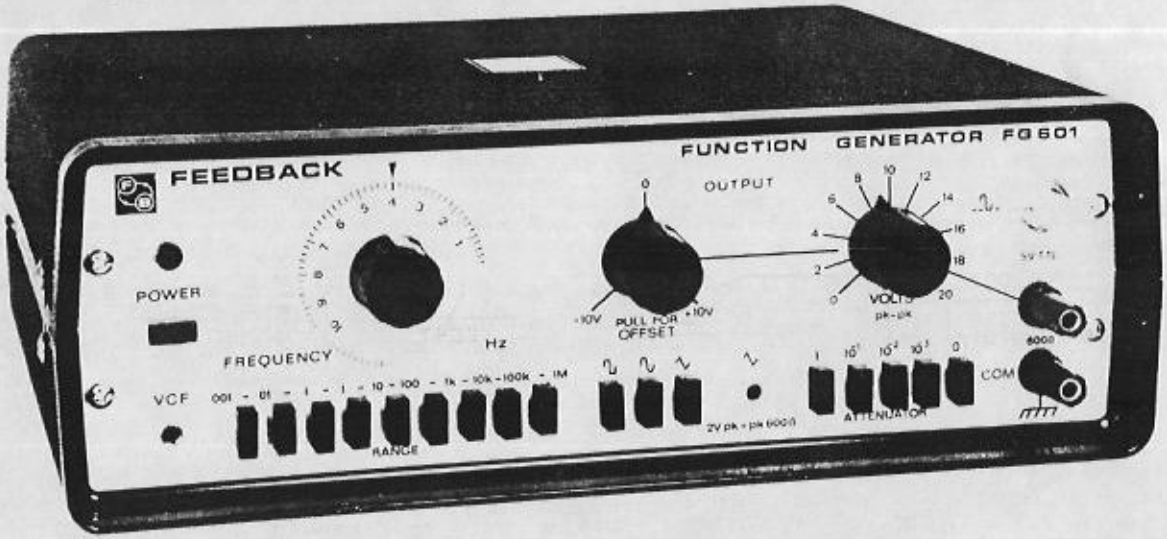
Function Generator
FG 601



FEEDBACK

Function Generator FG601

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Manual 601 *EdF 0482*

Printed in England by F I Ltd Crowborough

Component replacement

Although this Feedback manual was believed to be correct at the time of printing, components supplied may differ slightly from those described.

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Whenever possible, replacement components should be similar to those originally supplied. These may be ordered direct from Feedback Instruments Limited or its agents by quoting the following information:

1. Equipment type
2. Equipment serial number
3. Component reference
4. Component value

Standard components can often be replaced by alternatives available locally.

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We are required under the Health and Safety at Work Act 1974, to make available to users of this equipment certain information regarding its safe use.

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If, in specific cases, circumstances exist in which a potential hazard may be brought about by careless or improper use, these will be pointed out and the necessary precautions emphasized.

While we attempt to give the fullest possible user information in our handbooks, if there is any doubt whatsoever about any aspect relating to the proper use of this equipment the user should contact the Product Safety Officer at Feedback Instruments Limited, Crowborough.

DESCRIPTION

SECTION 1

1.1 Introduction

The Feedback FG601 function generator is based on an 'integrator and switch' circuit, fig 1.1. This generates triangular and square waveforms. The triangular waveform is then shaped by a non-linear amplifier to provide a sinusoidal waveform. Any of these three waveforms may be selected to feed the output amplifier. The output amplifier provides a current which is connected to the slider of the 600Ω output resistance thus providing an output voltage from a true 600Ω output impedance. An adjustable d.c current source is also connected to the 600Ω output and provides the offset. The waveform thus generated is connected through the switched ladder attenuator to the output terminals. The frequency of oscillation is set by the combined action of a capacitor in the integrator, which is switched to provide the decade ranges and a current supplied to the integrator. This current is generated by applying a voltage across a resistor and switching the value of the resistance to provide additional decade ranges. This voltage is the sum of that set by the frequency control and that applied to the VCF input. Special additional outputs are also provided:

i) a TTL square wave is provided for use as a clock to logic circuits

ii) a triangular wave is provided for various time base applications

The generator contains its own internal regulated power supply for operation on normal line voltages.

1.2 Mechanical

The FG601 is housed in an ABS plastic case made in two halves each secured by two screws on each side. The case provides the main structural strength of the instrument. Removal of the case gives access to all components. Without the cover the FG601 consists of a horizontal PWB fixed by small plastic brackets to the front and rear panels, providing a structure strong enough for normal handling and maintenance. The low power dissipation of the FG601 obviates the need for ventilation holes.

All controls are situated on the front panel fig 1.2. They are:

Power	Red pushbutton power switch Separate red power indicator
Frequency	Nine black pushbutton range selectors Fine frequency control with calibrated transparent dial.
Amplitude	Single rotary control
Attenuator	Five black pushbuttons
Offset	Single rotary control with 'push' for off

Waveform Selector	Three black pushbuttons	Monitor Output	4mm socket
Output Terminals	Main output from a pair of Red and Black 4mm socket binding posts. TTL output from BNC socket	VCF input	4mm socket

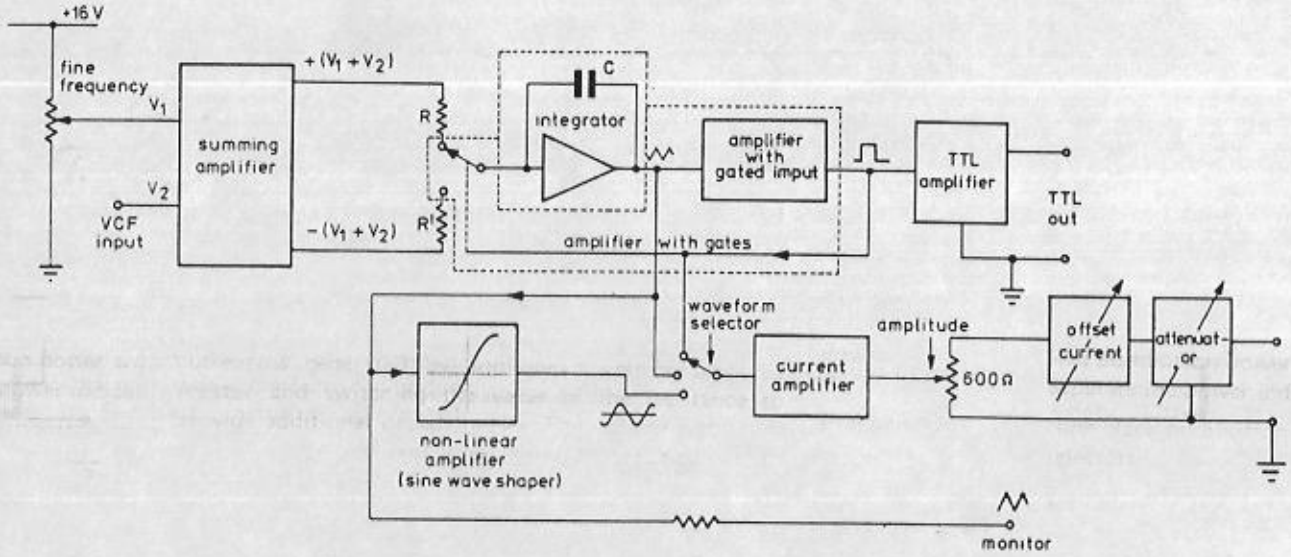


Fig 1.1

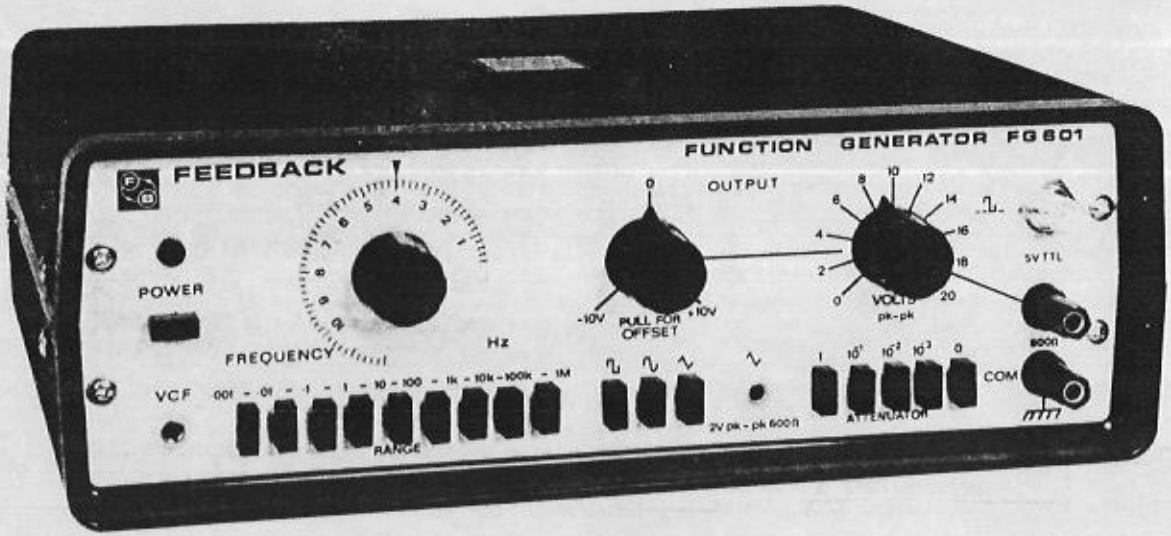

FUNCTION GENERATOR FG601
FEEDBACK
POWER
FREQUENCY
Hz
VCF
RANGE
OUTPUT
-10V
PULL FOR OFFSET
+10V
VOLTS
pk-pk
5V TTL
COM
ATTENUATOR

Fig 1.2

1.3 Specification of type FG601

The FG601 is a general-purpose, solid state, sine, square and triangular waveform generator with VCF capability.

Frequency

Range
0.001Hz to 1.0MHz in nine pushbutton controlled ranges.

Range overlap
20% at top of each range and 90% nominal at bottom.

Scale accuracy
±5% of full scale. Typically ±2% of indication from 1 to 10 on dial scale.

Frequency Stability
Measured at 10kHz on 1kHz to 10kHz range.

Drift Typically 0.03% per 10 minutes, measured after 10 minutes warm up.

Temperature coefficient Typically $+230 \times 10^{-6}$ deg C^{-1}

Supply voltage change Typically 0.003% of frequency for 10% change in supply voltage

Main Output

Waveforms
Sine, Square, Triangular with pushbutton selection.

Source impedance
600Ω

Amplitude control

Single continuous control calibrated 0 to 20V pk-pk at nominal 2V pk-pk intervals.

Stepped attenuator, five pushbuttons selecting
X1.0, X0.1, X.01, X.001 and 0.
Accuracy @ 1.0kHz:
X0.1 ± 2%
X.01 ± 4%
X.001 ± 6%

Amplitude
20V pk-pk maximum open circuit

Amplitude stability

Sine and square waveforms Typically < ±0.5% pk-pk change over the range 0.01Hz to 100kHz.

Triangular waveform Typically < ±0.5% pk-pk change over the range 0.01Hz to 10kHz and -2.5% at 100kHz.

Variation in voltage Typically 0.02% of amplitude for 10% change in supply voltage measured at 1kHz on 100Hz to 1kHz sine wave range.

Temperature coefficient Typically $<30 \times 10^{-6}$ deg C^{-1} at 1kHz on 100Hz to 1kHz sine wave range.

Offset

DC offset Control coupled with push-pull switch to disconnect offset.

Magnitude from +10V nominal continuously adjustable through 0V to -10V nominal on X1.0 attenuator

setting. DC offset is unaffected by adjustment of Main Output continuous amplitude control but is attenuated together with the signal by the pushbutton attenuator.

Limiting Combinations of DC offset and signal which add up to more than + or −10V peak may cause limiting.

Terminations

4mm binding posts (Hi-red and Lo-black) on ¾in pitch.

Purity

Sine distortion < 0.6% at 1kHz on 100Hz to 1kHz range

Rise and fall time < 100ns on square wave

Linearity Typically < 1.0% on triangular wave at 1kHz

Jitter Typically < 20ppm average cycle period difference from mean value measured at 1Hz.

Auxiliary Outputs

Triangular wave

Amplitude 2V pk-pk

Impedance 600Ω

Termination 4mm socket

TTL Square wave

Amplitude a) TTL compatible (nominal 0 to +5V). b) with 50Ω load, 0V to approximately +0.6V

Rise time O/C or 50Ω load < 10ns

Sink capacity Twenty standard TTL loads

Termination BNC

VCF

Control characteristic

Linear

Sensitivity

+1.0 volt applied to VCF socket increases frequency set on dial effectively by 1 major scale division.

Sweep range

Two decades

Slew rate

0.2V/μs referred to input

Input impedance

10kΩ

Termination

4mm socket

Power Requirements

Line voltage

200/250V or 100/125 rms 50 or 60Hz

Consumption

16VA

Fuse
315mA slow blow (20mm x 5mm)
Littel fuse style 213
Beswick T DC 123
Buss GMA

Dimensions and Weight

Width	300mm (12in)
Height	100mm (4in)
Depth	225mm (9in)
Weight	2.2kg (4.8lb)

SECTION 2

OPERATION

2.1 Installation of FG601

The function generator is packed in inserts of expanded polystyrene to prevent damage in transit. On opening the end of the corrugated cardboard container the inserts together with the FG601 should be smoothly withdrawn from the container. Take care that the inserts and FG601 are held together during this time.

Inspect the FG601 and if any damage is evident immediately notify the carriers.

2.2 Voltage selection

Ensure that the instrument is set to the appropriate voltage supply either by inspecting the tag (if fitted) on the power cable or by removing the top cover of the instrument.

The voltage selection is accomplished by a slide switch on the printed circuit board on the side of the FG601. The switch locking plate must be removed to enable the switch to be operated. Set the switch to '115' for operation from 100 to 125V and '230' for 200 to 250V, 50/60Hz AC.

Wire connections. The colour code of the power supply cable is:

Brown	Live
Blue	Neutral
Green/Yellow	Ground

The ground wire is connected to the front and back panels of the FG601 and to the common terminal on the front panel.

2.3 Frequency Selection

Any value of frequency in the range 0.001Hz to 1.0MHz may be obtained by use of the range switch and fine frequency control. The pushbutton range selectors provide the following frequency decades:

.001Hz to .01Hz
.01Hz to 0.1Hz
0.1Hz to 1.0Hz
1.0Hz to 10Hz
10Hz to 100Hz
100Hz to 1kHz
1kHz to 10kHz
10kHz to 100kHz
100kHz to 1.0MHz

The required frequency is set by the variable control, graduated 1 to 10. For example to set 3.6kHz press the 1 to 10kHz button and turn the variable control to 3.6.

2.4 Outputs

Main output A required output waveform is selected by pushing one of the three waveform selection buttons. The amplitude of the output waveform is set by the output

control knob calibrated from 0 to 20V peak-to-peak and is the open circuit or no-load voltage. The output impedance is 600Ω and any loading will cause the output voltage to be lower. In particular if loaded with 600Ω the terminal voltage will be half that indicated.

DC offset If required this is obtained by pulling the *offset* knob and rotating it clockwise for positive offset and counterclockwise for negative offset. Pushing the knob disconnects the offset no matter where the knob is positioned. On the attenuator range X1.0, if an attempt is made to select a combination of offset and a signal greater than 10V peak, some limiting may occur.

Offset only With all three waveform selection push-buttons in the out position the offset voltage only is available at the output terminals.

Attenuator The output attenuator enables the signal selected by the continuous amplitude control together with the output offset selected (if any) to be reduced by a factor of 10, 100 or 1000. The extreme left-hand attenuator pushbutton feeds the signals straight through without attenuation while the extreme right-hand button gives zero output while maintaining a 600Ω output impedance.

TTL Output This output is intended primarily for use as a clock waveform for TTL logic. It has a current sinking capacity suitable for up to twenty normal TTL loads. The output impedance is not constant but the output voltage should still be sufficient for TTL operation with resistive loads of 400Ω or more.

Monitor Output This output is a high purity triangular waveform primarily intended for use as a time base when one of the other outputs is used as a driving function.

2.5 Output phases

The phase relationship between the various outputs is shown with reference to the monitor in fig 2.1.

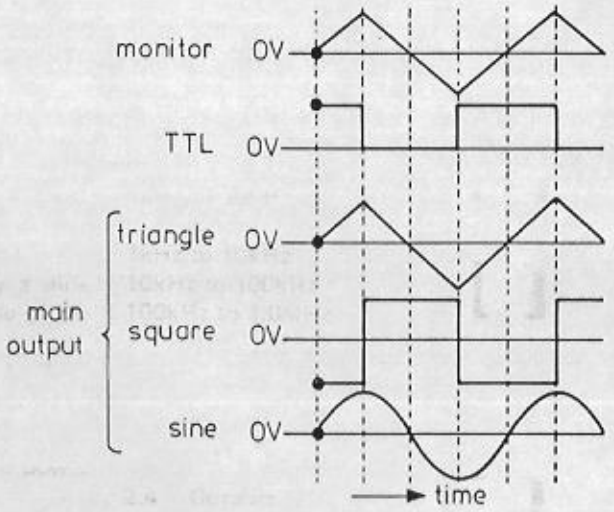


Fig 2.1

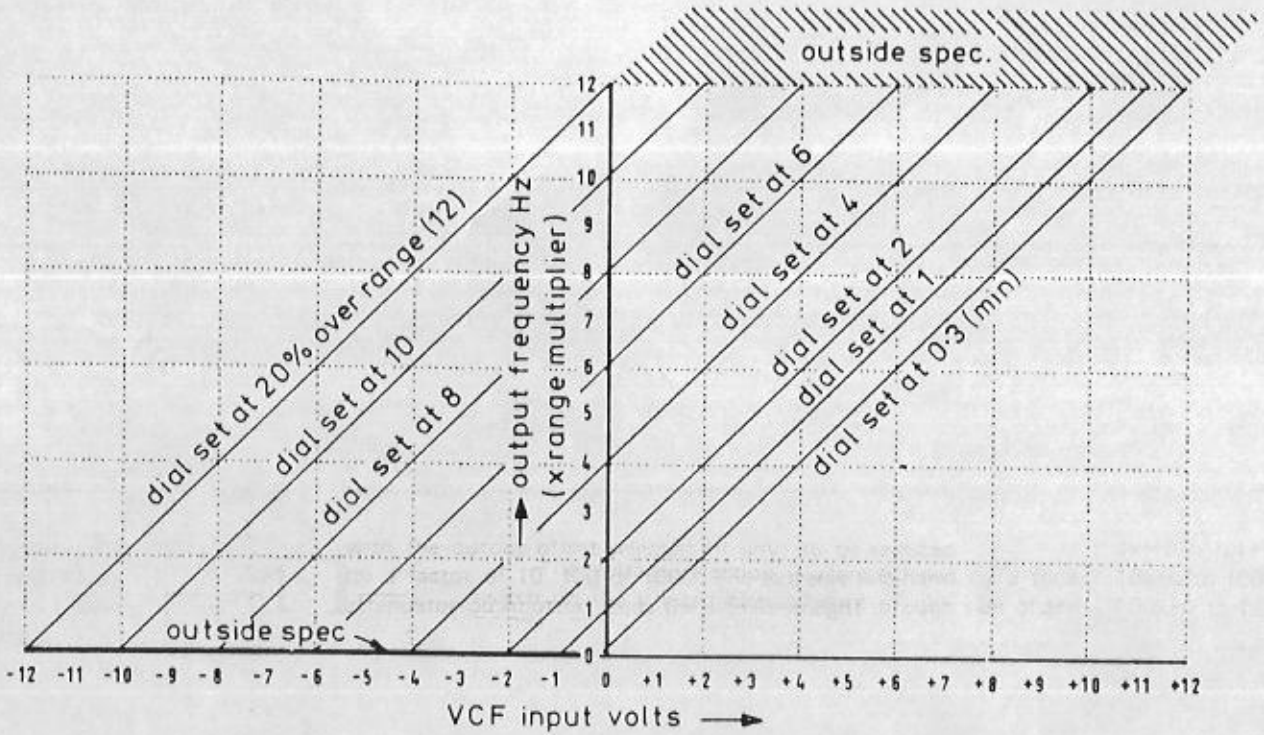

outside spec.
dial set at 20% over range (12)
dial set at 10
dial set at 8
dial set at 6
dial set at 4
dial set at 2
dial set at 1
dial set at 0·3 (min)
output frequency Hz
(x range multiplier)
outside spec
VCF input volts
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10 +11 +12
0 1 2 3 4 5 6 7 8 9 10 11 12

Fig 2.2 VCF voltage/output frequency for various dial settings

VCF input The VCF (Voltage controlled frequency) input enables the frequency of oscillation to be controlled by an external signal.

Fig 2.2 shows the linear characteristics of this control and enables suitable conditions to be chosen for a given application. A positive voltage applied to the VCF increases the frequency and a negative voltage decreases it at a rate of one major division per volt. The frequency should not be driven much beyond the top of the selected frequency range. By application of a negative voltage the frequency can be reduced to a point where oscillation ceases.

2.6 Phase Measurement

Measurement of the phase shift of a signal in a system under test may be made as in fig 2.3. Usually a +ve voltage on the Y and X inputs of the oscilloscope moves the spot upwards and to the right respectively. This may be verified by short-circuiting the system to obtain zero phase shift. The display can be arranged symmetrically about the X axis as in fig 2.4, i.s a = a'.

To simplify calculations it is convenient to adjust the X deflection to be nine scale divisions as in fig 2.5.

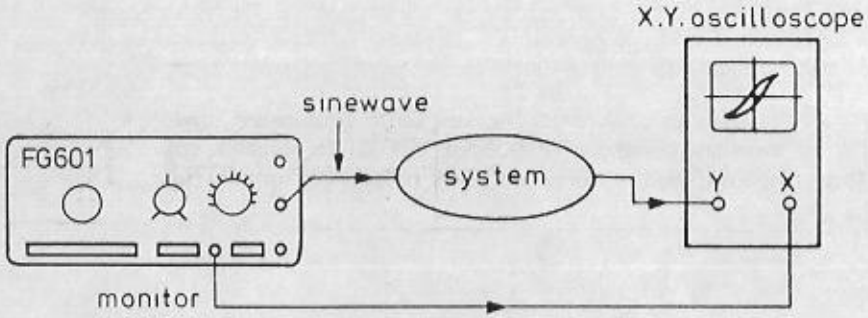
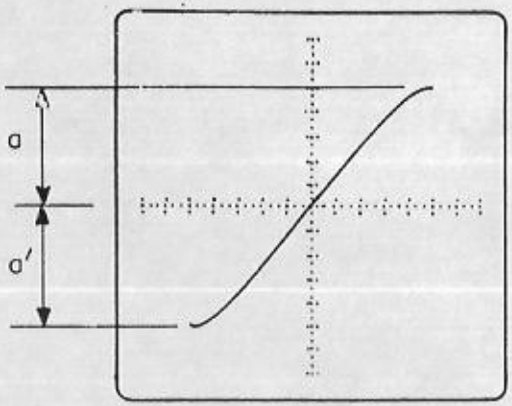
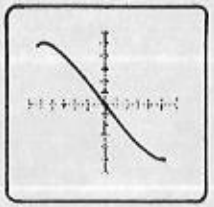


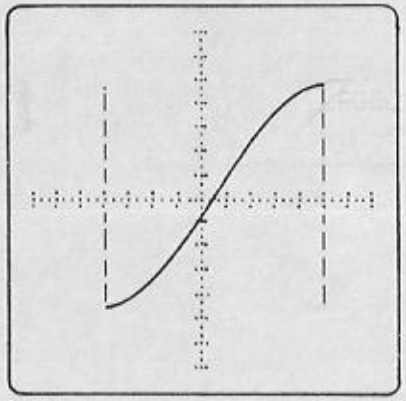
Fig 2.3

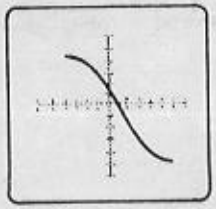




display for positive X moves spot to left

Fig 2.4

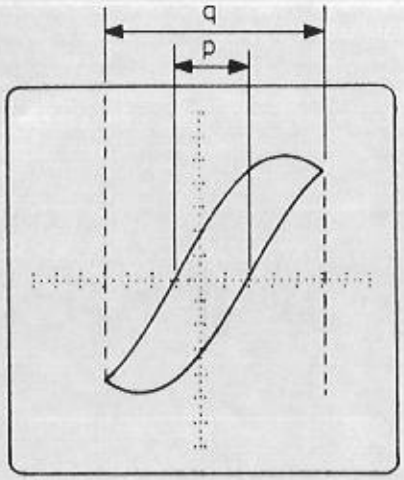


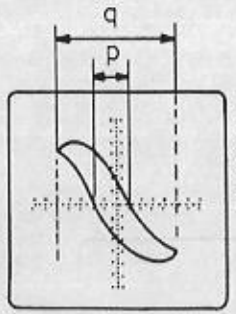


display for positive X moves spot to left

Fig 2.5

The phase angle in fig 2.6 is then given by $90° \times \frac{p}{q}$ but since q was adjusted to equal nine divisions the phase angle becomes simply $(10p)°$.





display for positive X moves spot to left.

Fig 2.6

When the angle is greater than 90° then display will be in the form of fig 2.7.

In this case the angle is $180^\circ - (90^\circ \times \frac{p}{q})$

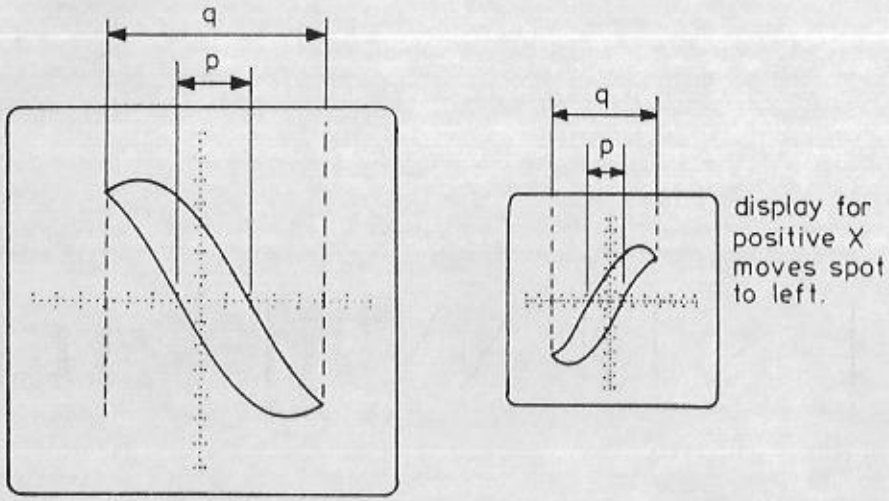
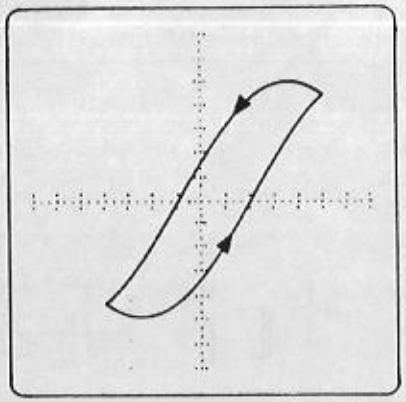


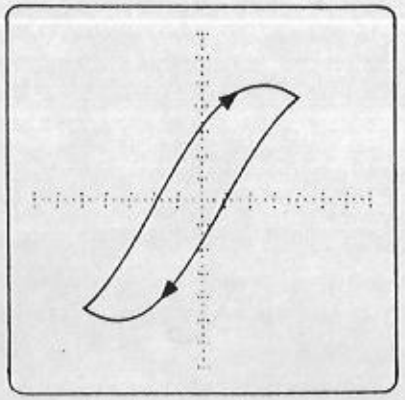
Fig 2.7

It is sometimes not known if the angle is leading of lagging. At low frequencies (as will often be the case in servo systems) this can be found by noting the direction in which the spot traces the loop as in fig 2.8.



Anticlockwise → lagging

(leading for positive X moves spot to left)



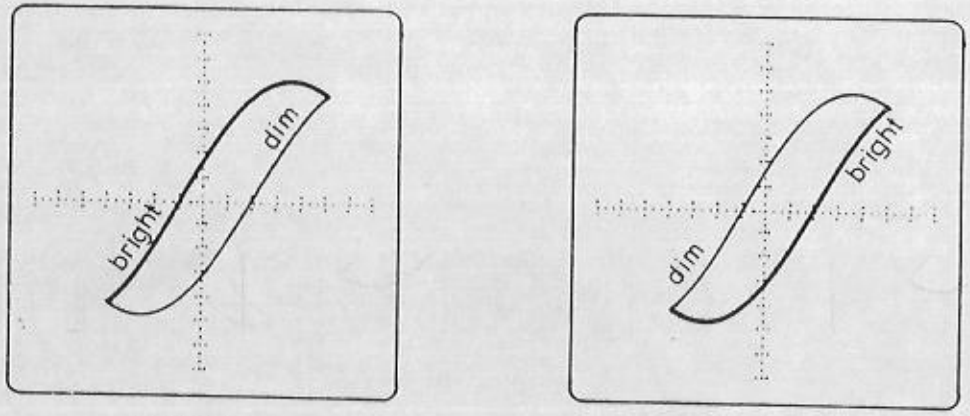
Clockwise → leading

(lagging for positive X moves spot to left)

Fig 2.8

At higher frequencies it may be necessary to use the TTL output of the FG601 on the 'Z modulation' of the oscilloscope; this will brighten one half of the trace. Assuming that a +ve voltage brightens the trace then the phase is identified as in fig 2.9.

If a +ve input voltage to the Z modulation dims the trace, the two conditions are reversed.



lagging
(leading for positive X moves spot to left)

leading
(lagging for positive X moves spot to left)

Fig 2.9

2.7 Transient Response Measurement

Use the test circuit of fig 2.11. The monitor triangular output then acts as a time base.

Put the output waveform on to the Y plates, adjust the FG601 until the transient occupies the oscilloscope screen as shown in fig 2.10.

The time $T = \frac{1}{2F}$ where F is the frequency setting

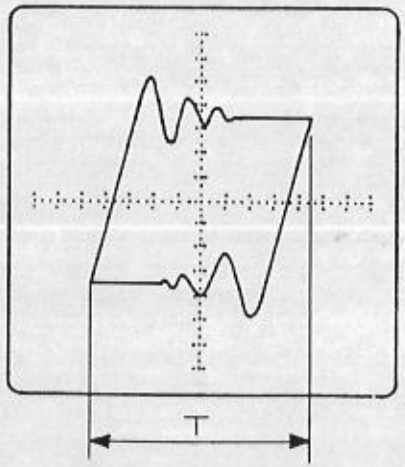


Fig 2.10

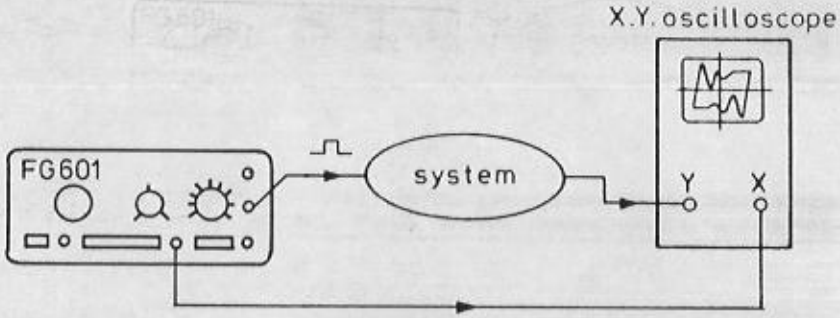


Fig 2.11

2.8 Measurement of following error

When a servo mechanism or voltage follower is excited by a linear ramp of R volt/sec, after an initial transient the output follows the input but with a 'following error' E_f.

The method illustrated in fig 2.12 displays this error as a gap between the forward and return traces. For servos a 'velocity constant' K_v is defined.

$$K_v = \frac{R}{E_f} \quad \text{where } R = \frac{\text{pk to pk amplitude of drive}}{\text{time for one half cycle}}$$

$$E_f = \frac{\text{vertical gap in volts V}}{2}$$

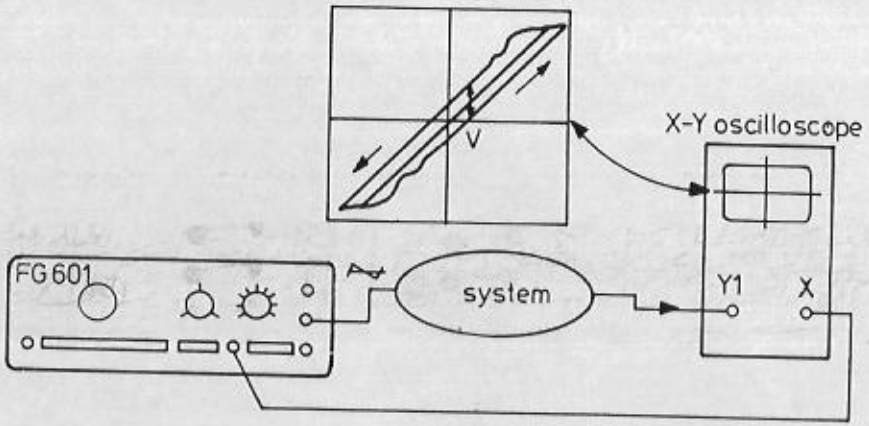


Fig 2.12

2.9 Automatic frequency response testing

The diagram of fig 2.13 shows a typical circuit configuration for automatic frequency response testing using the FG601 with oscilloscope, and Feedback FS502 Frequency Sweeper.

The FS502 incorporates an oscilloscope marker pulse for location and accurate frequency measurement of peak and null points. Similar results can also be obtained without marker facilities, using a suitable externally generated ramp, e.g ramp generator or oscilloscope time base output.

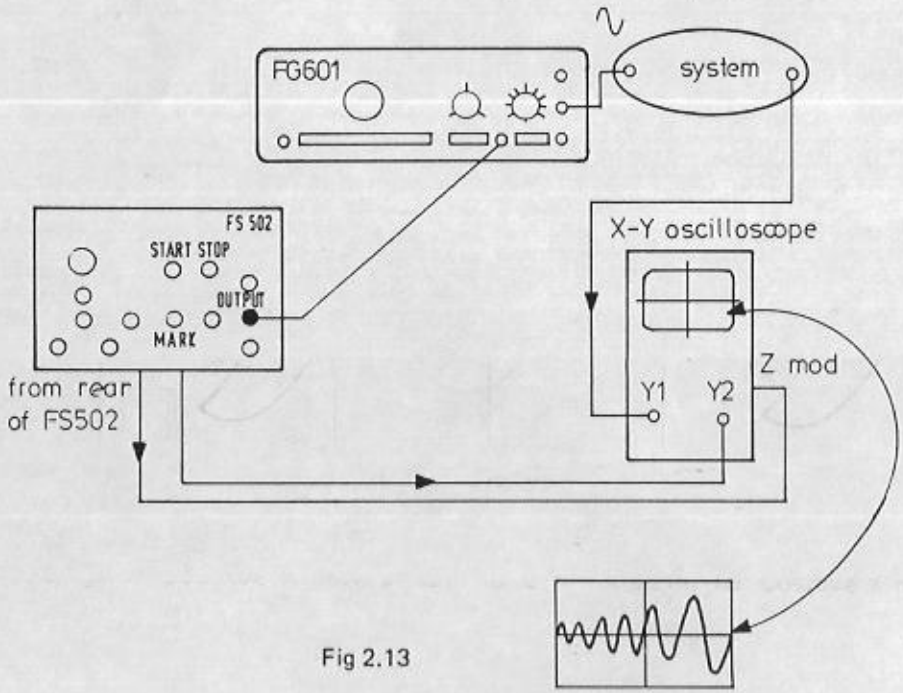


Fig 2.13

CIRCUIT DESCRIPTION

For simplicity the diagrams shown in this section are in block diagram form. The components referred to in the text can be found in the full circuit diagram, fig 4.2.

3.1 Switch Amplifier

The switch amplifier, fig 3.1, generates the control square waveform from which the three function waveforms provided by the instrument are developed. The circuit consists of two bridge diode gates and an amplifier with a ±0.6V output to drive the gates.

Diodes D12-15 gate the input current into the integrator. The diodes D1-4 act with resistors R41-45 to switch the input current, in the switch amplifier, in response to the integrator output level.

The amplifier is formed by transistors TR8-11 connected as a pair of balanced Darlington amplifiers. Transistors TR8 and TR11 have a high current gain while TR9 and TR10 are low storage types providing a fast switching action.

Considering the action of gate 2, while the integrator is generating a negative-going ramp, the input to the switching amplifier V_{in} will remain positive until $V_{in} = -16(R41/(R42 + R43))$ volts.

When V_{in} becomes zero the feedback output of the amplifier A becomes zero. This causes a portion of the current flowing through R42, 43 to flow through D1.

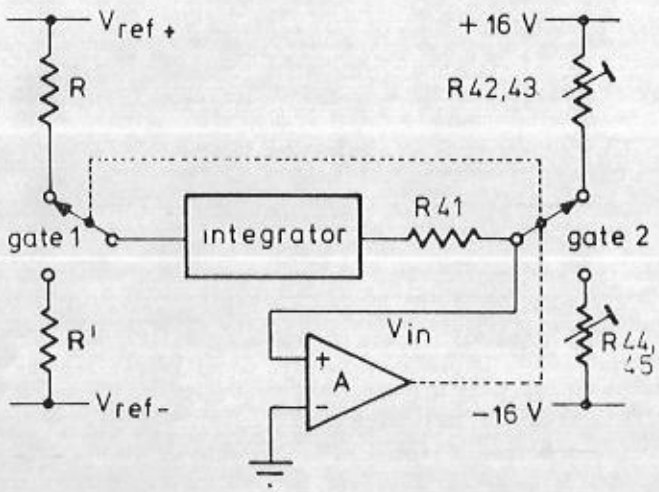


Fig 3.1

The input potential to TR8 is reduced, producing a regenerative swing to the negative (-0.6V) output limit. A -0.6V instead of +0.6V feedback signal then appears at the input to gate 1. The potential across diode D14 now becomes zero, causing current to flow through diodes D15 and D12 producing a reversal of the signal polarity at the input of the integrator. A positive-going ramp is then started by the integrator and will continue

until V_{in} = +16(R41/(R44 + R45)) volts, when the circuit will switch to its original condition.

3.2 The Integrator

The integrator generates a ramp that is transformed into a triangular waveform by the switching action of the square wave with the ramp slope determining the frequency of oscillation.

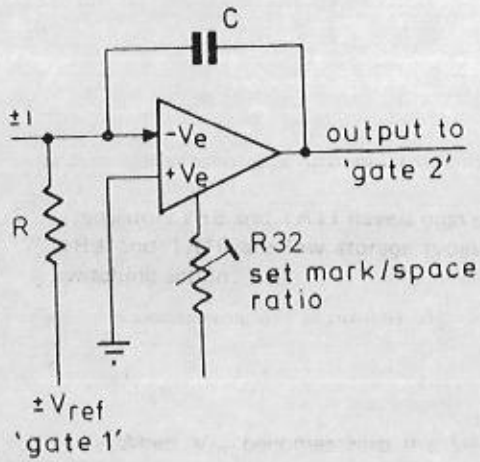


Fig 3.2

The input stage is formed by a dual balanced field effect transistor TR1. Transistor TR3 forms the voltage amplifier stage with transistor TR6 connected as an emitter follower output. Current sources are provided by transistors TR2, 4 and 7. Capacitor C7 and resistor R39 ensure that there is stable operation of the circuit.

Frequency of the triangular waveform output is determined by the reference voltage into the integrator and by the RC constant formed by the choice of capacitors C1-6 and the resistor pairs R10, R20, R12,22, R14,24 and R16,26 at the input to the integrator.

Resistor R27 adjusts the input d.c level of the gate, pin 3, of the field effect transistor TR1. By this means the mark/space ratio of the square waveform can be set to unity. The resistor also takes up any offset that amplifier AC may introduce into the input of the integrator.

3.3 Integrator Current Generator

The integration current generators fig 3.3 produce equal and opposite voltages to the frequency range resistors. Variation of these voltages alters the current flowing into the integrator and hence the frequency of the triangular waveform. The circuit is formed by three operational amplifiers AA, AB and AC together with a fine frequency potentiometer control and VCF input.

Connection of the potentiometer is across the +16V supply with the potential on the slider being buffered by the voltage follower AA. This minimises the loading and

ensures a linear scale on the frequency dial. The voltage from this buffer is added to any voltage at the VCF input of AB arranged as a summing amplifier. Finally AC produces the equal and opposite voltage to the frequency range resistors. R_4 is used to set the maximum frequency calibration.

The diodes D13 and D15 need a forward voltage to conduct and this voltage detracts from the frequency determining resistor voltage. To compensate partially for this, diode D11 is included in the feedback of AB. This diode also compensates for the non-linear resistance characteristic of the other diodes and provides temperature compensation. Accurate range-to-range compensation for the diode characteristic is provided by the additional voltages developed by R11,13,15,17 and 18, and R21, 23, 25, 27 and 28.

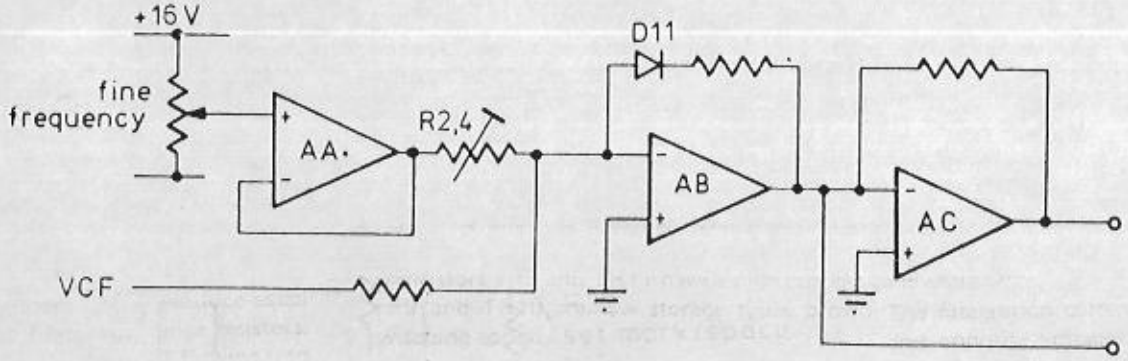


Fig 3.3

3.4 Sine Shaper

The sine shaper makes use of the non-linear characteristics of an overdriven long-tailed pair fig 3.4, and is formed by the transistor arrays TR32 to 40.

Inclusion of suitably placed resistors will modify the characteristics, as in fig 3.5.

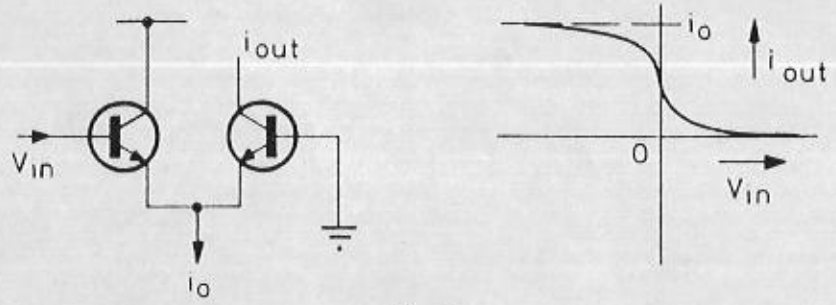


Fig 3.4

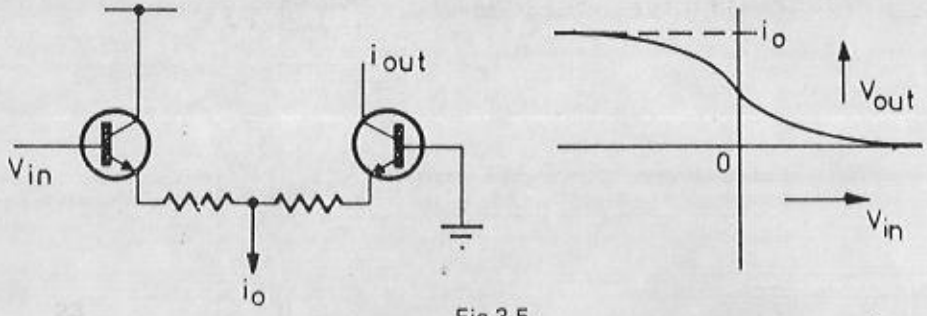


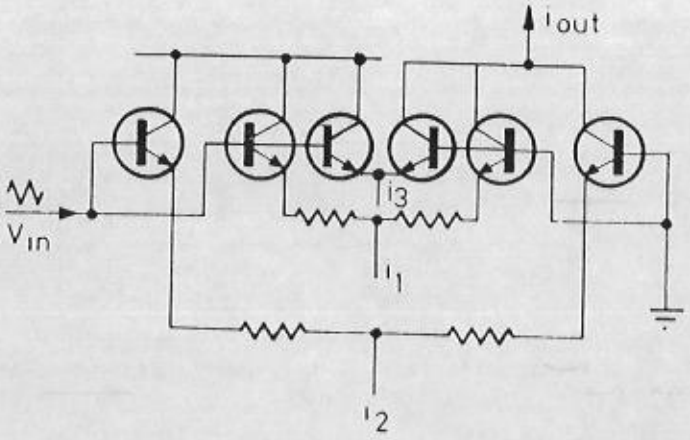
Fig 3.5

By connecting three such circuits in parallel, fig 3.6, and using resistors R61,62,63 and 64, a transfer characteristic which will shape the triangular waveform into a sinusoidal waveform, is obtained.

3.5 Output Amplifier

The output amplifier is a current amplifier in which transistors TR18 and TR19 are a grounded base input stage to which the various function circuits are permanently connected. The circuits providing these function waveforms are activated by connection by the front-panel pushbuttons to the -16 volts supply rail: TR32 to 40 generates the sine current, TR14 and 15 the triangular current, and TR16 and 17 the square wave current waveform.

Transistors TR20 and 21 form the current amplifier with a current gain of about X3.7. This current flows through the grounded base output transistor TR25 into the amplitude control variable resistor R98 thereby generating the output voltage. Transistors TR22 and 23 set the bias voltages for the output 'totem pole' of TR24 to 27 while TR24, 26 and 27 are used to generate constant currents.



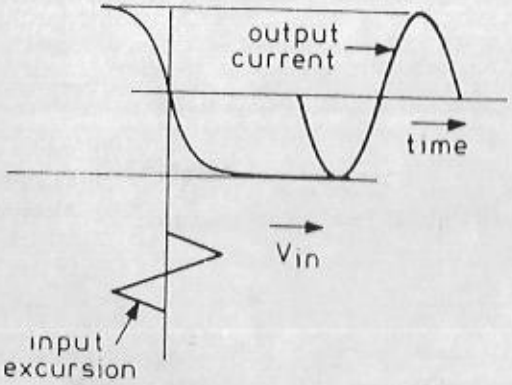


Fig 3.6

Offset The DC offset generator employing TR28 to 31 produces an adjustable positive or negative current which is connected to the output resistance TR98 and TR99. Adjustment is effected by varying the bias differentially on TR29 and 30. Transistors TR28 and 31 are biased into saturation so that when S20 is open neither transistor passes any current and any offset current is reduced to zero.

Output Attenuator This is a series of 'L' sections connected by the pushbutton switches between the output resistance TR98 and 99 and the output terminals. The output impedance of the attenuator sections is 900Ω. This is shunted by R118 to provide a true 600Ω output impedance.

3.6 TTL Output

The TTL output is provided by transistors TR12 and TR13 with TR12 being switched on and off by the output of the switching amplifier. Transistor TR13 is mounted close to the output socket on the front panel to give the best possible waveform.

3.7 Power Supply

The FG601 circuits operate on a regulated ±16 volt supply with regulation by an IC dual regulator AD. Resistors R119 and R120 provide a current limit at about 120mA in the event of power line short circuit. An unregulated supply of ±25 volts smoothed by capacitors C22 and C23 provides the voltage supply to the regulator. These ±25V lines also supply the operational amplifiers AA, AB and AC.

The mains transformer has a double primary winding connected in series for 200-250V operation and in parallel for 100 to 125V supplies. Voltage selection is conveniently effected by a slide switch positioned on the side PWB.

MAINTENANCE

4.1 Fault Location

Faults will appear as abnormal outputs from the function generator. The variety of simultaneous outputs from the FG601 allows a certain narrowing of the area in which the fault is located.

The function generator has been designed to allow access to all components by removal of the case.

First remove the handle by pulling it outwards at each end in turn, thereby releasing each centre cap. This needs firm pressure. Then remove, with a Posidriv No 2 screwdriver, the four screws on each side of the case (two of which are in the handle boss).

The top and bottom halves of the cover can then be lifted off. The chassis formed by the PWB and front and rear panels is strong enough for normal handling during maintenance.

On replacing the handle, caps and then rotate them until t

The handle also acts as re-positioned by easing outv simultaneously.

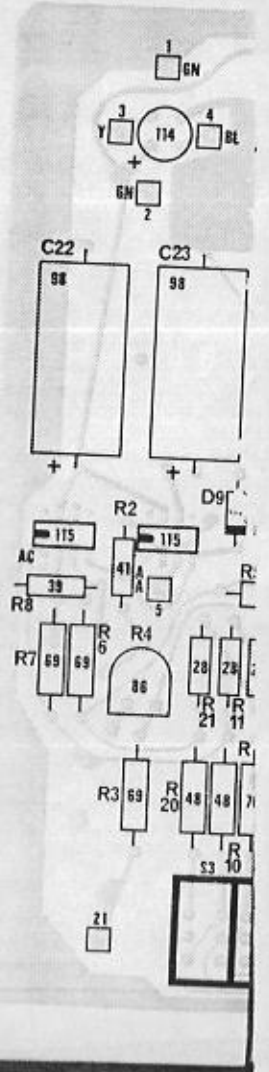
Positions of the compo referred to in the following ta reference to fig 4.1a and 4.1b a diagram of fig 4.2.

4.2 Setting Procedure for Cont

Before assuming a fault conditic controls are not in need of adjust

The following is a list o malfunctions that can occur, properly set.

Control	*Check*	*Frequency*		*Possib*
		Range	*Dial setting*	
R4	Frequency calibration	1 to 10kHz	10	Calibr frequ
R32	Unity mark/space ratio of square wave	1 to 10kHz	1	Mark/ botto Failu of all



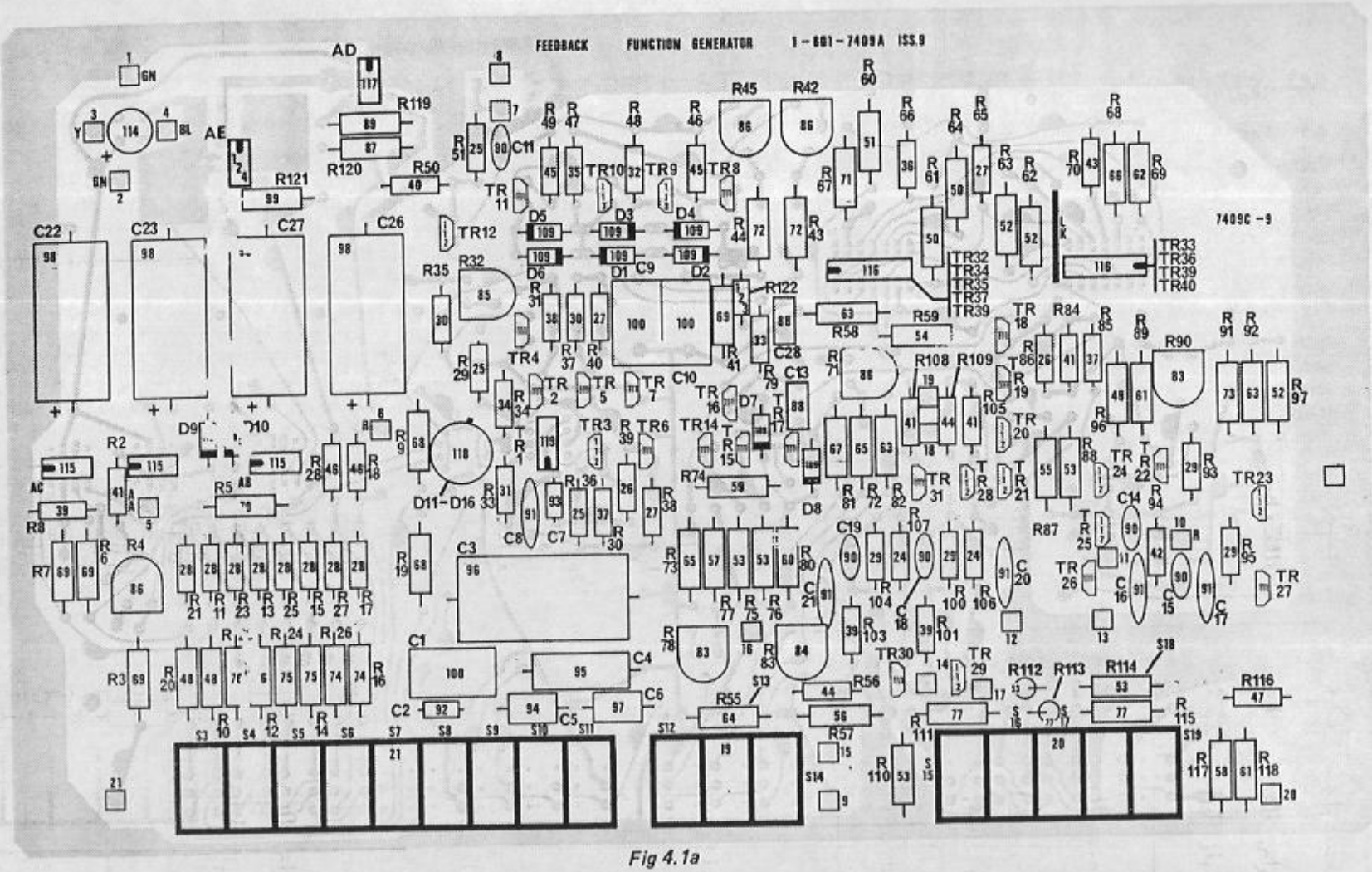


Fig 4.1a

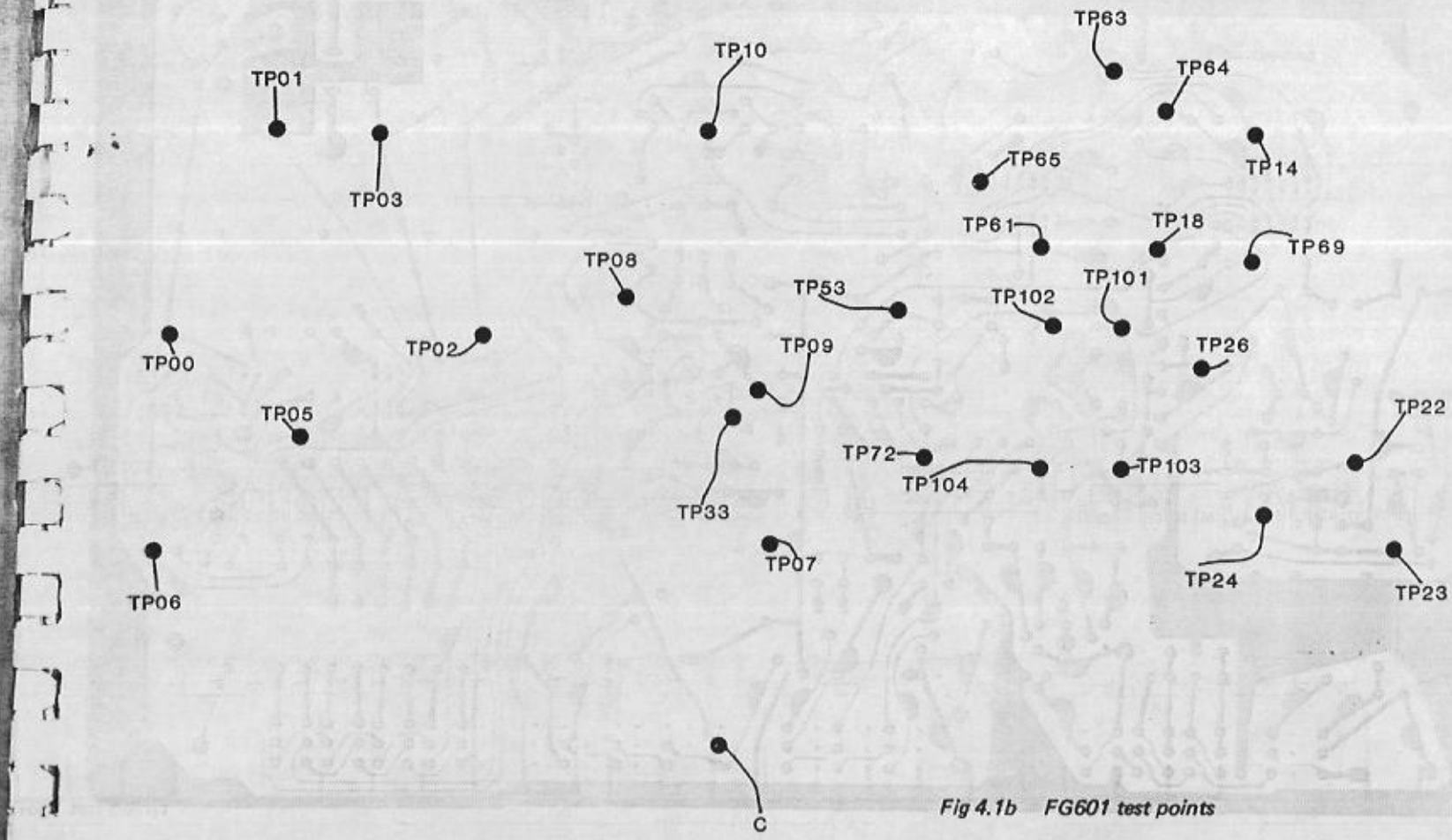


Fig 4.1b FG601 test points

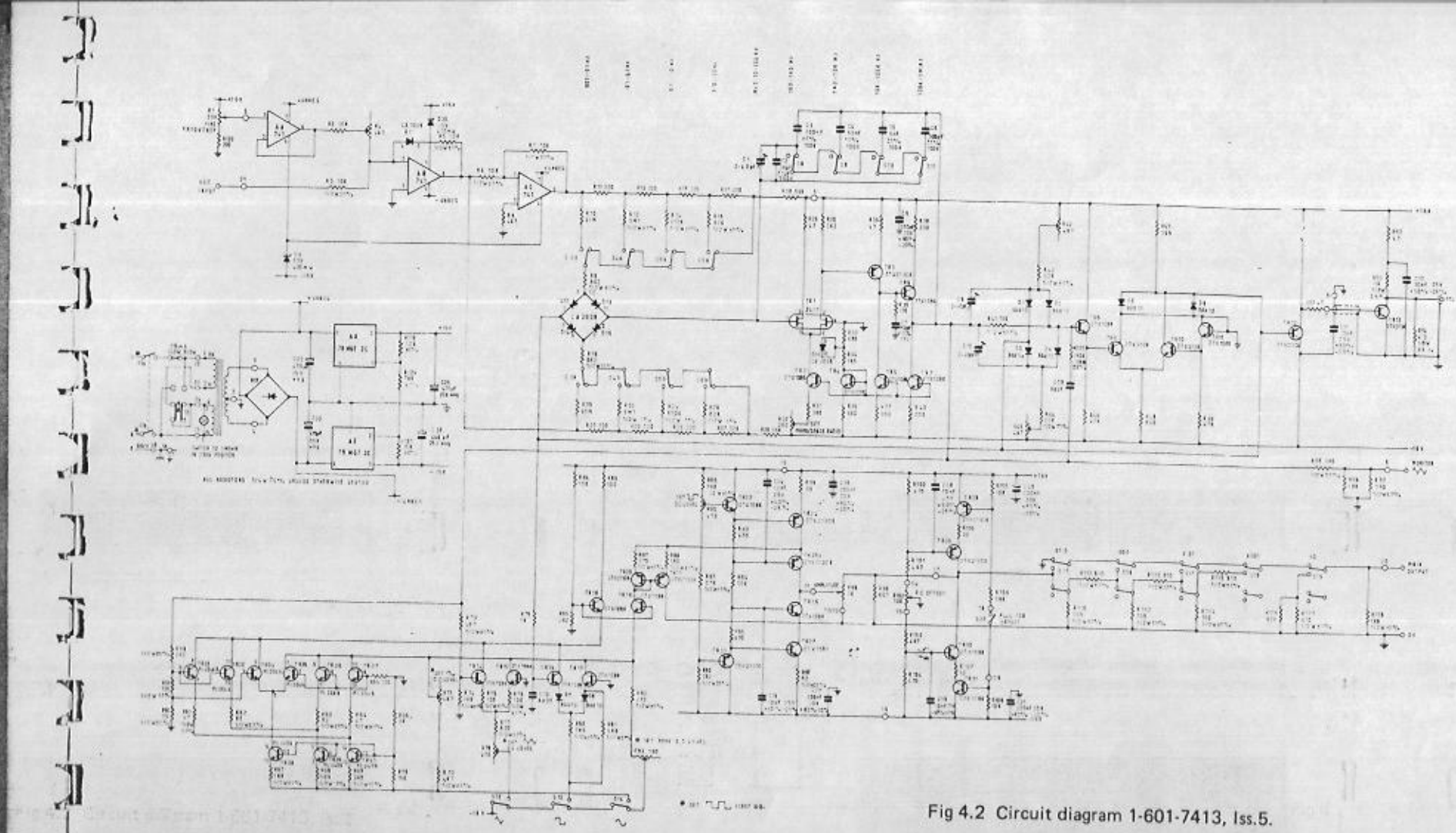


Fig 4.2 Circuit diagram 1-601-7413, Iss.5.

C1	Frequency calibration top range	100kHz to 1MHz	2	Frequency calibration error on all of top range only.
R42	Distortion of sinewave	100 to 1kHz	10	Misshapen top (+ve) of sinewave plus minor frequenc and amplitude errors at all frequencies.
R45	Distortion of sinewave	100 to 1kHz	10	Misshapen bottom (-ve) of si wave plus minor frequency a amplitude errors at all frequencies.
R71	DC on sinewave output			DC on sinewave output. Clipping of waveform
R77	DC on main triangular wave output			DC on main triangular wave output. Clipping of wavefor
R90	DC on main square wave output	1 to 10kHz	10	DC on all main outputs. Clipping of waveform.
R83	No waveform selected			DC on main output termina
C9	Distortion of sinewave	100kHz to 1MHz	10	Misshapen bottom (-ve) of sinewave, DC on both triang waveforms, top frequency error.

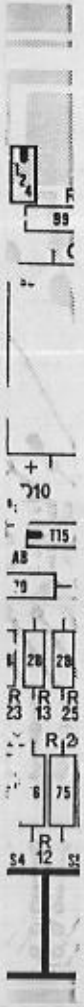
C10	Distortion of sinewave	100kHz to 1MHz	10	Misshapen top (+ve) of sine wave, DC on both triangular waveforms, top frequency error.
R121	+ & - 16 volt lines			General calibration errors

4.3 Diagnostic Table

Unless otherwise stated, set the controls on the instrument as follows:

Frequency range	100Hz to 1kHz
Frequency dial	10
Output amplitude	Maximum
Waveform	Sine

Symptom	*Test point*	*Correct output at Test point*	*Probable location of fault*
Power indicator lamp not lighting	Check supply voltage. Check fuse	Voltage in range 100-125V or 200-250V	Power supply
Malfunction in general	02 03 00 01	+16V -16V ±.2V +20 to +25V -20 to -25V	Power supply Regulator



No main outputs Monitor output still present	26 22 23 24	+10V +2.7V pp sinewave +11.1V -11.1V 22V pk to pk sinewave with no DC.	Output Amplifier
No main outputs or monitors	05 06	-12.6 +12.6	Integrator current generator
	07 10	>-6V | or | >+6V -0.6V | or | +0.6V	Switch circuit TR8-11
No main outputs or monitor	08 C 33 09 07	-12.2V OV ±50mV +15.2V +0.6V DC } +12V OV DC } p/p/Triangle	Integrator
Sine output −DC	C 33 09 07	+0.7V +16.0V -14.6V -10.6V	
Sine output +DC	C 33 09 07	-0.7V +14.4V +13.5V +12.8V	

No main square waves, others functioning	Select square wave by pushbutton 53 72	±0.7V see fig 4.3 -.7V -1.4V } see fig 4.4	Square wave output current switch TR16, 17
No main sine wave Others functioning	69 18 14 61 63 64 65	+2.8V +2.2V -1.9V ±0.5V Triangle See fig 4.5 See fig 4.6 See fig 4.7	Sine shaper
Wrong offset but proper or clipped waveforms	Offset switch pulled out 101 102 103 104	+15.4V -15.4V +15.5 to +16V } varies with - 15.5 to - 16V } offset control position.	Offset circuit TR28-31
	Offset switch pushed in 101 102 103 104	+16V -16V +4 to +12V } measure with -4 to -12V } 20kΩ/V meter	

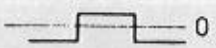


Fig 4.3

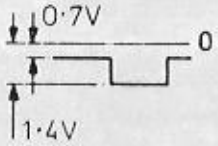


Fig 4.4

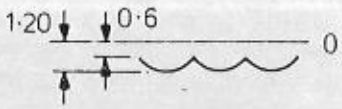


Fig 4.5

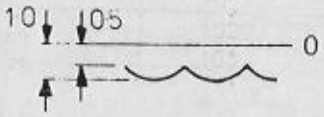


Fig 4.6

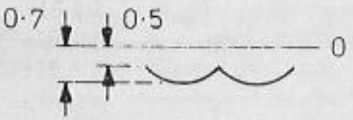


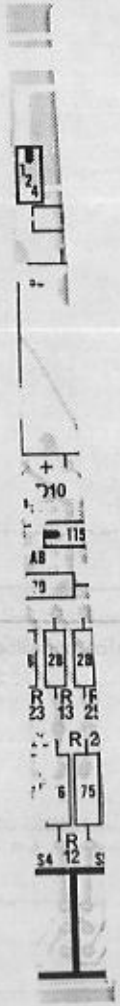
Fig 4.7

4.4 Alignment Schedule

The following is a systematic procedure for adjusting a working FG601 to specification. It is not a fault-finding procedure. An oscilloscope, timer counter and distortion meter are used.

Remove top and bottom covers of case and then:

Connection	*Range Setting*	*Frequency dial setting*	*Alignment*	*Observation or Adjustment*
Voltmeter to +16V line			Power lines	Set R121 to give +16V and check -16V line to be -16V ±0.2V
Oscilloscope to main output	10 - 100kHz	Fully clockwise	Square Waveform	Switch offset off. Turn amplitude to maximum. Adjust preset R90 control to bring main waveform output symmetrically about ground.
Oscilloscope to main output	1 - 10kHz	Anti-clockwise	Square Waveform	Adjust R32 to give unit mark/space ratio
Oscilloscope and distortion meter to output	100 - 1kHz	10	Sine waveform	Set oscilloscope to observe a large display. Adjust R42 and R45 to give minimum discontinuity at peaks of waveform. Then check distortion on distortion meter.
			OR	
Distortion meter to main output	100 - 1kHz	10	Sine waveform	Adjust R42 and R45 to give minimum distortion. Track instrument frequency change by adjusting distortion meter.



Oscilloscope to main output	1 - 10kHz		Sine waveform	Adjust R71 to bring main output waveform symmetrically about ground
Oscilloscope to main output	1 -10kHz	10	Triangular waveform	Adjust R78 to bring main output waveform symmetrically about ground.
			Check all three waveforms	Maximum amplitude to be 20V +2V peak-to-peak
Oscilloscope on main output			All waveform buttons out	With output control at maximum set DC output level to zero with R83
			Control knobs	The two control knobs on the front panel are collet fixed. To remove the cap it must first be prised off using a thin blade. This reveals the collet nut which must be turned anti-clockwise with a box spanner while knob is held steady. (See fig 4.9)
Frequency meter or Timer counter	1 -10kHz		Frequency dial	The collet knob is slackened so that the dial may be turned to the '1' position on the dial with the frequency set to 1kHz. The nut is then tightened and the dial turned to read '10', i.e 10,000Hz and the oscillator is brought to this frequency by adjustment of R4. It may be necessary to repeat the above process if a large adjustment of R4 is necessary. (See fig 4.8)

Frequency meter or Timer counter	0.1 to 1.0Hz and 100kHz to 1MHz *simultaneously*	10	Top frequency range	Adjust C1 to give 10kHz
Frequency meter or Timer counter and Oscilloscope	100kHz to 1MHz	10	Top frequency range and sinewave	Adjust C9 and C10 to bring frequency to 1.0MHz and also to give symmetrical (top and bottom) sinewave
Apply +9V d.c to VCF input	100 -1kHz	1	All waveforms	Check that frequency of oscillator changes to 1kHz ±50Hz.

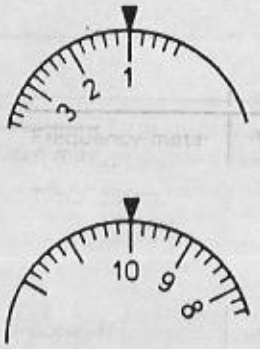
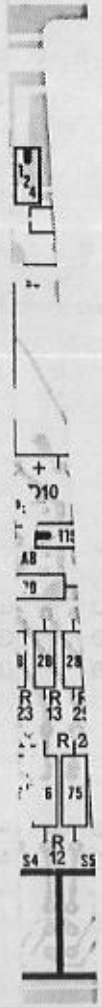


Fig 4.8

Fig 4.9



4.5 Component Replacement Table

The function generator is not critical with regard to component types but proper performance can only be expected if componenets are replaced by reasonably similar types.

A brief general specification of suitable components is listed together with a look-up table.

Component	*Spec*	*Component*	*Spec*	*Component*	*Spec*	*Component*	*Spec*	*Component*	*Spec*
Resistors								Capacitors	
R1	F	R31	A	R61	D	R91	D	C1	–
R2	A	R32	E	R62	D	R92	D	C2	L
R3	D	R33	A	R63	D	R93	A	C3	L
R4	E	R34	A	R64	D	R94	A	C4	L
R5	D	R35	A	R65	A	R95	A	C5	L
R6	D	R36	A	R66	A	R96	D	C6	L
R7	D	R37	A	R67	D	R97	D	C7	K
R8	A	R38	A	R68	D	R98	G	C8	N
R9	D	R39	A	R69	D	R99	A	C9	–
R10	A	R40	A	R70	A	R100	A	C10	–
R11	A	R41	D	R71	E	R101	A	C11	N
R12	D	R42	E	R72	D	R102	C	C12	N
R13	A	R43	D	R73	D	R103	A	C13	K
R14	D	R44	D	R74	D	R104	A	C14	N
R15	A	R45	E	R75	D	R105	A	C15	N
R16	D	R46	A	R76	D	R106	A	C16	N

(continued on page 41)

| | | |

C	10kΩ switched potentiometer with switch pull to make	½W nominal	20% or less	3/8" bush fixing ¼" shaft 13/16" long from mounting face.	R102.
D		1/8W or more	1% or less	PWB hole centres 0.8" Resistor dia. 0.2" or less	R3, 5, 6, 7, 9, 12, 14, 16, 19, 22, 24, 26, 41, 43, 44, 55, 57, 58, 59, 60, 61, 62, 63, 64, 67, 68, 69, 72, 73, 74, 75, 76, 77, 80, 81, 82, 87, 88, 89, 91, 92, 96, 97, 110, 111, 112, 113, 114, 115, 116, 117, 118.
E	Preset potentiometer	0.1W or more	20% or less	See fig 4.10	R4, 32, 42, 45, 71, 78, 83, 90, 121. (Cermet or carbon track)
F	Wire wound or Cermet 25kΩ potentiometer	3W nominal	±20%	3/8" bush fixing, shaft 13/16" long from mounting face	R1
G	1kΩ potentiometer	1W nominal	±5%	3/8" bush fixing, ¼" shaft. 13/16" long from mounting face	R98
H	Slow blow fuse	315mA	Delay or anti-surge	20mm x 5mm dia.	
K	Ceramic, mica or plastic capacitors	15V working	±20% or less	PW hole centres 0.3" or 0.2" hole centres	C7, 13, 24, 25

L	Polystrene dialectric capacitor	100V working	1% or less	Inspect PWB for max. space available	C2, 3, 4, 5, 6.
M	Electrolytic capacitor	35V working	-20+80%		C22, 23, 26, 27.
N	Disc ceramic capacitor	20V working or more	+50-25%	PWB hole centres 0.3"	C8, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21.

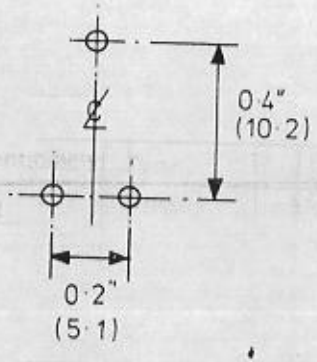


Fig 4.10

Transistors

If the Ferranti transistor types are not available the following types bearing EIA or Pro-Electron type numbers may be used. This table does not imply that the types listed are equivalents in any other situation.

Ferranti	EIA	Pro-Electron
ZTX108	2N930	BC108
ZTX313	2N2369	BSX20
ZTX213c	2N3251	BC178
	1N914	BAX13

Other components are listed below with the Manufacturers name.

Circuit ref	Type No	Manufacturer
TR1	E412	Siliconix
AD	MC1468R	Motorola
TR32 to 40	CA3046	RCA
D11 to 16	CA3039	RCA

Other components including mains transformer and pushbutton switches are supplied to Feedback specifications and should be ordered through Feedback Instruments Limited, Crowborough, Sussex.